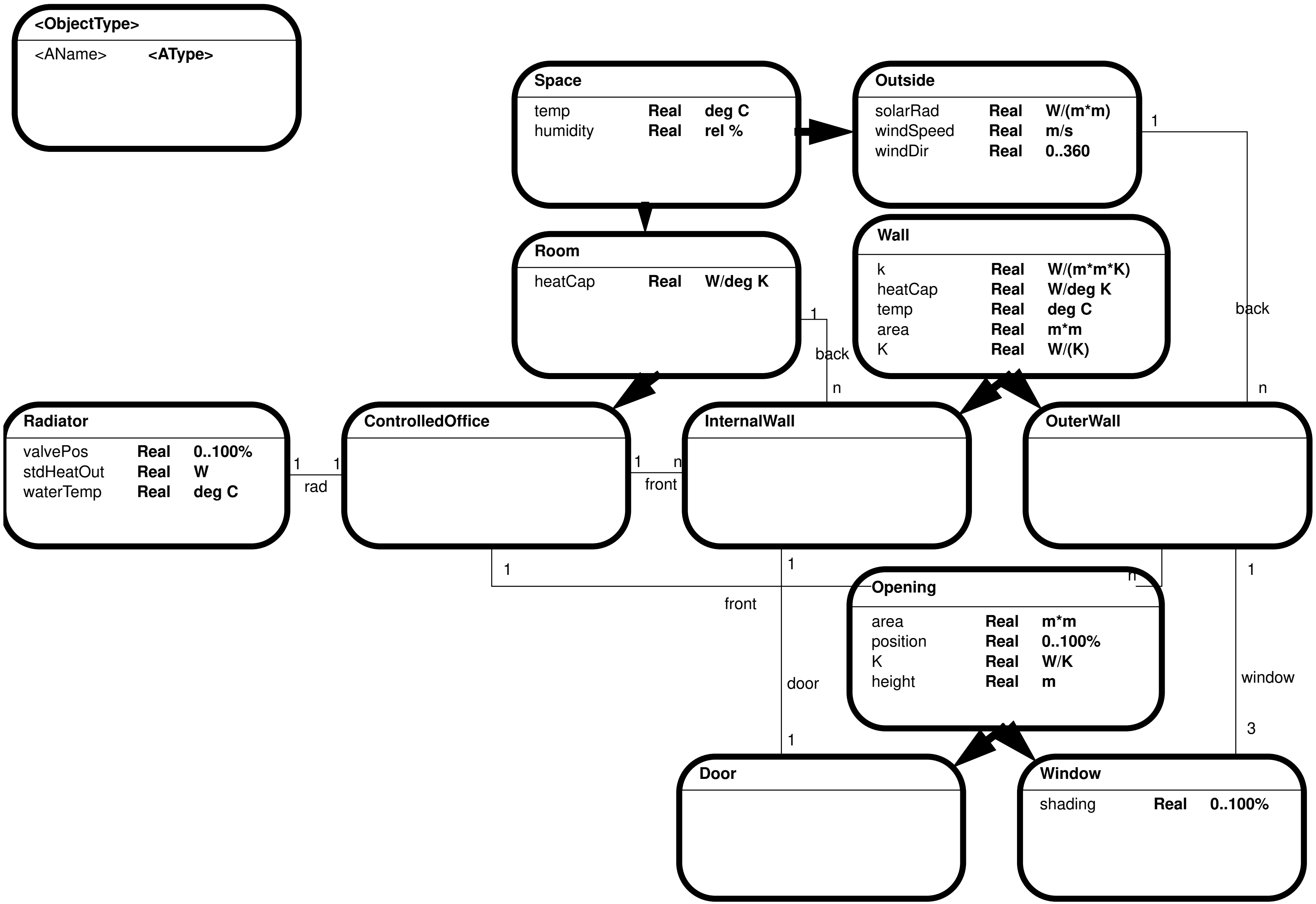
1 Organizational Aspects

Project:	**Building Automation System**
Subproject:	**Team 1 Constraint Model**
Documenttype:	**Reference Model**
Documentname:	**~d1/team1models/ConstraintModel.v?**
Responsible:	**SFB501-D1**
User:	**Team1**
Description:	Models for constraints.

Version#	**Date**	**Creators**	**Remarks**
v1	5.12.95	Schuetze	first ideas
v1.1	8.1.96	Schuetze	reorg & corrections
v1.2	19.1.96	Schuetze	slight reorg & additions

2 Object Model



3 Object Behavior

General Remarks

Object behavior is defined in tables which associate the behavior with the current object ***mode***. Two general modes are distinguished: simple and detailed mode. Typically, all formulas in simple mode yield results for asymptotic calculations. Therefore, the simple mode is appropriate whenever the building is operated near to a steady state. E.g., the temperature is to be changed only a few degrees after it stayed nearly constant for a longer period of time. Detailed mode is only needed for dramatic value changes. Please keep in mind that all physical parameters are only known with limited precision, that means that you can NOT expect to calculate values 100% correctly, even in detailed mode!

3.1 ControlledOffice

Table 1: Behavior of ControlledOffice

<table>
<tr><th colspan="3">Mode</th><th>Temperature</th><th>Windows/ Sashs</th></tr>
<tr><td rowspan="6">simple (experimental)</td><td rowspan="3">summer</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td rowspan="3">winter</td><td rowspan="3"></td><td>temp development
$\vartheta(t) = \vartheta_{Max} - (\vartheta_{Max} - \vartheta(t_0))\, e^{\frac{-(t-t_0)}{\tau}}$
heat-up time
$t = \tau \ln\left(\frac{\vartheta_{Max} - \vartheta_{act}}{\vartheta_{Max} - \vartheta_{nom}}\right)$
Outside Temp / ϑ_{Max}

-5 ˚C / 21.5 ˚C
0˚C / 21.5 ˚C

τ :
optimistic: 2000s
best fit: 2500s
conservative: 3250s</td><td>closed</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

Table 1: Behavior of ControlledOffice

<table>
<tr><th colspan="2">Mode</th><th>Temperature</th><th>Windows/ Sashs</th></tr>
<tr><td rowspan="7">detailed (cal-culated)</td><td rowspan="3"></td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td rowspan="3">all seasons</td><td>total heat flux
$$\dot{Q}_{bal} = \dot{Q}_N + \dot{Q}_e + \dot{Q}_{hl}$$
$$\dot{Q}_N = (light + person + equip)$$
$$\dot{Q}_e = \sum_{walls} \dot{Q}_{f,\,wall}$$
$$\dot{Q}_{hl} = (solarRad) + \dot{Q}_{HK}$$</td><td rowspan="3">*</td></tr>
<tr><td>heating/cooling
$$\vartheta(t) = \vartheta(t_0) + \frac{1}{\text{heatCap}}\int_{t_0}^{t} \dot{Q}_{bal}$$</td></tr>
<tr><td></td></tr>
</table>

3.2 Wall

3.3 InternalWall

Table 2: Behavior of InternalWall

<table>
<tr><th colspan="3">Mode</th><th>Temperature</th><th></th></tr>
<tr><td rowspan="6">simple</td><td colspan="2" rowspan="3"></td><td>front heat flux (pos. result == gain), asymptotic
$$\dot{Q}_f = K \cdot (\text{back.temp} - \text{front.temp})$$</td><td></td></tr>
<tr><td>back heat flux, asymptotic
$$\dot{Q}_b = -\dot{Q}_f$$</td><td></td></tr>
<tr><td>total transmittance
$$K = \text{area} \cdot k + openings$$</td><td></td></tr>
<tr><td rowspan="3"></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>detailed</td><td colspan="2"></td><td></td><td></td></tr>
</table>

3.4 Radiator

Table 3: Behavior of Radiator

Mode			**Temperature**	
simple			standard heat output (taken from lit) $\text{stdHeatOut} = 3000W$	
			heat output coefficient $K_{HI} = \frac{\text{stdHeatOut}}{70°C}$	
			heat output $\dot{Q}_{HK} = K_{HI} \cdot \text{valvePos} \cdot \Delta T$ $\Delta T = \text{waterTemp-rad.temp}$	
			water temperature (preliminary experimental) outside temp / water temp: ... 0 C / 60 C 5 C / 55 C 10 C / 50 C ...	
detailed				

3.5 Opening

Table 4: Behavior of Opening

Mode			Air exchange	Temperature	Opening
simple	ventilation		Air exchange $\dot{V} = \text{see subclass}$	front heat flux !!! window dito!!! $\dot{Q}_{fo} = \dot{V} \cdot \Delta\vartheta \cdot \frac{1200 Ws}{m^3}$ $\Delta\vartheta = \text{door.back.temp} - \text{door.front.temp}$ back heat flux $\dot{Q}_{bo} = -\dot{Q}_{fo}$	*
detailed					

3.6 Window

Table 5: Behavior of Window

Mode			Radiation	Temperature	Window
simple	radiation		constant trans-mission ratio g=0.9	radiation load $\dot{Q}_S = E_v \cdot g \cdot \text{shading} \cdot \text{area}$	closed
detailed					

3.7 Outside

Table 6: Behavior of Outside

Mode	Radiation	Temperature	Window
*		temp >= -12 degC	

4 Additional Constraints

4.1 ControlledOffice

4.2 Wall

4.3 Internal Wall

4.4 Radiator

We have no control over the water inlet temperature. However, we assume that water is always hot enough to keep 20 deg C in room with windows and doors closed.

4.5 Opening

All calculations are based on the assumption that there is no wind.

4.6 Window

4.7 Outside

5 Definitions & Explanations

5.1 ControlledOffice

Do not mix simple and detailde mode!

Simple mode based upon experimental studies with limited accuracy.

ϑ_{Max}	upper bound for the temperature in the office with windows, etc. closed and heating installation set to 100%. Experimental value!
ϑ_{asy}	theoretical upper value of the room temperature, based on internal heat gains and loss of the controlled office.
$\vartheta(t)$	temperature of office at time t. Current value is bound to attribute *temp.*

5.2 Wall

k	coefficient for the energy loss through wall **material**, measured in Watt per square meter and degK temp difference
heatCap	heat storage capacity of the complete wall, measured in Watt per degK temp difference
K	coefficient for the total energy loss through the wall, including doors and/or windows

5.3 Internal Wall

5.4 Radiator

All three radiators are modeled as one single radiator.

5.5 Opening

5.6 Window

E_v	radiation vertical on surface. Formula valid for visible light as well as for solar radiation.

5.7 Outside

solarRad	Solar radiation in Watt per squaremeter on vertical surface directed to the south
windSpeed	wind velocity in m/s
windDir	win direction in degrees TN (true north)